Introduction

This document describes the firmware functionalities of the M24SR-DISCOVERY board. This document helps the user to understand how this firmware works.

M24SR can communicate with an MCU, this make M24SR a dynamic tag. Indeed the reader (for instance a smartphone) can retrieve different content staying close to the M24SR.

The reader communicates with the M24SR-DISCOVERY board through the 14443A protocol. The MCU communicates with the M24SR by an I^2C bus. The MCU of the M24SR-DISCOVERY is an STM32F103.

With this discovery kit, the M24SR can be programmed with different content following the NFC forum format. This means that a smartphone can read it natively without any specific application previously installed. Then depending on the content, its behavior can change regarding the smartphone and the OS version.

A proprietary mode has also been developed, to illustrate other ways to use the M24SR; in this case, a specific application must be installed. (Available only for Android smartphones).

Note: *All information content in this document is applicable for M24SR-DISCOVERY Standard and Premium editions, unless otherwise specified.*

This documentation was written with M24SR discovery firmware version v1.1.1; the board is delivered with software version v1.1.0; the differences between these releases are only due to the cleaning of code, mainly for the Doxygen documentation. No functional modifications have been added.

Contents

List of figures

1 Overview

1.1 M24SR overview

M24SR is a dynamic tag IC for contactless applications (ISO 14443A). It manages the RF communication with a reader. It includes frame coding, RF modulation and manages the anti-collision process itself.

The M24SR works as an NFC Forum Type 4 tag, supporting the detection, the reading and the writing operations.

M24SR can communicate with a reader without any external control.

Figure 1. Communication chart
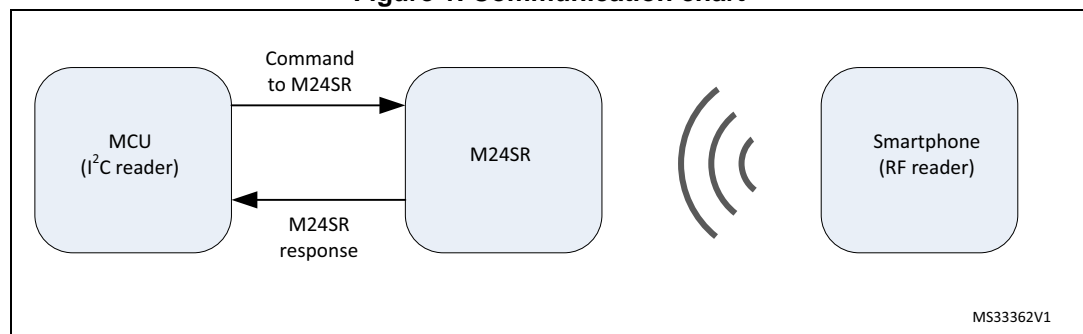
Note: *For more details concerning the M24SR device, refer to the corresponding datasheet.*

1.2 STM32F103 overview

The STM32F103xx integrates a high-performance ARM Cortex™-M3 32-bit RISC core operating at a 72 MHz frequency, high-speed embedded memories (Flash memory up to 128 Kbytes and SRAM up to 20 Kbytes), and an extensive range of enhanced I/Os and peripherals connected to two APB buses. All devices offer two 12-bit ADCs, three general purpose 16-bit timers plus one PWM timer, as well as standard and advanced communication interfaces: up to two I^2Cs and SPIs, three USARTs, a USB and a CAN.

These features make the STM32F103xx microcontroller suitable for a wide range of applications such as motor drives, application control, medical and handheld equipment, PC and gaming peripherals, GPS platforms, industrial applications, PLCs, inverters, printers, scanners, alarm systems, video intercoms, and HVACs.

1.3 M24SR-DISCOVERY board

The M24SR-DISCOVERY is an evaluation kit which allows to evaluate the performances of an ST M24SR dynamic tag.

The M24SR-DISCOVERY is powered through the USB bus and no external power supply is required. It includes an M24SR tag, a 31 x 30 mm 13.56 MHz double layer inductive etched antenna (no need of tuning components).

By default, the M24SR communicates with the STM32F103RG 32-bit MCU via the I^2C bus.

Figure 2. M24SR-DISCOVERY board (Premium edition shown)
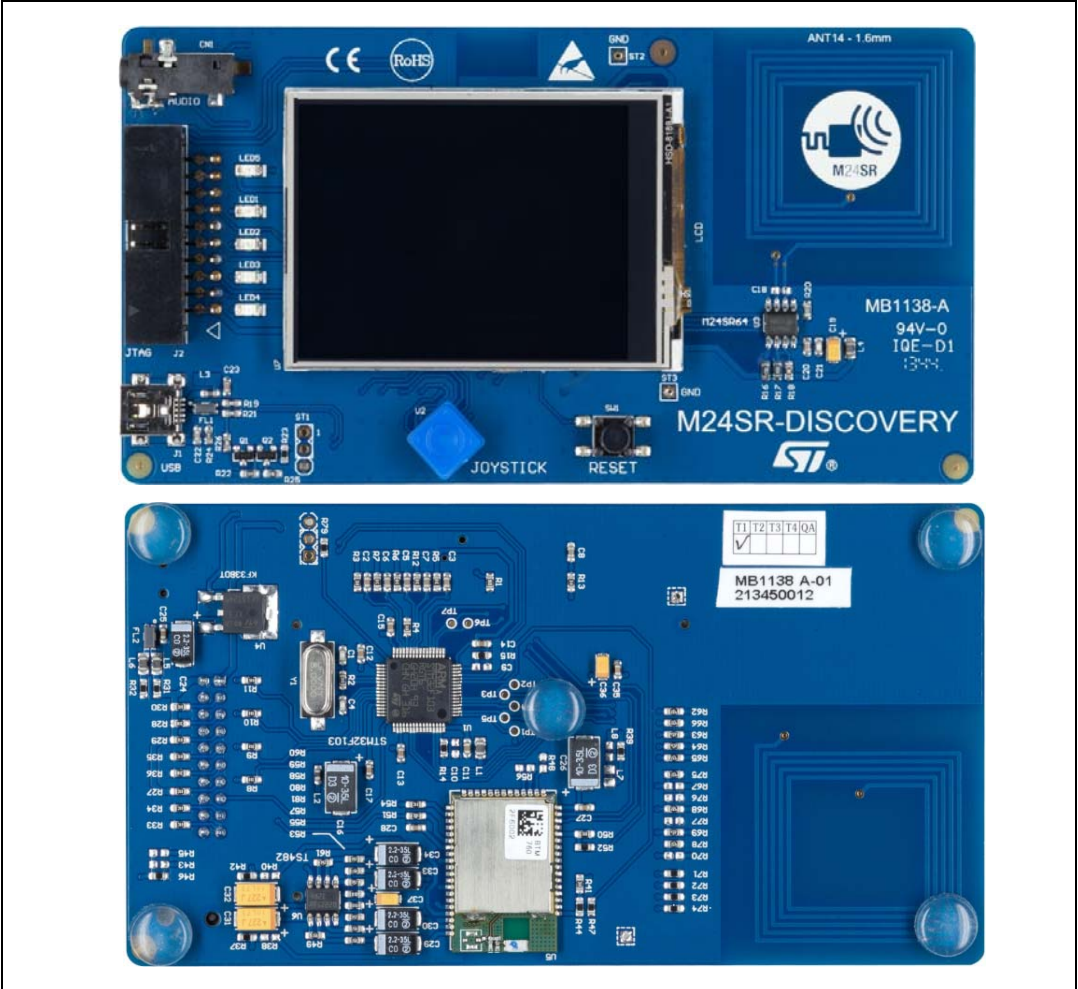
2 Firmware description

Prerequisite

The user has an NFC smartphone with the NFC capability enabled.

As M24SR is a dynamic tag, the interesting point is to show that a reader can see different content in front of the M24SR. For this purpose, the next examples have been thought to be performed with the interaction of the M24SR-DISCOVERY and a smartphone.

Note: *Reading the NFC forum content in the M24SR will be natively performed by your smartphone. But writing the NFC forum content will need to use a dedicated application.*

For this reason, the goal of the demonstration is to change the M24SR content by I^{2}C (with MCU) and check the updated content by RF (with smartphone). But it is also possible to change the M24SR content using your smartphone and to check the updated content with the MCU.

2.1 Main menu

The main menu is composed of icons allowing access to different items. Each item illustrates an M24SR use case.

Note: *On the Premium edition, one more icon is available to illustrate a Bluetooth pairing use case.*

The organization is as follows:
- NFC forum compliant example
  - URI item
  - SMS item
  - Email item
  - Vcard item
  - Bluetooth item (premium edition only)
  - Geolocation item
  - My App item (NFC forum compliant but needing a dedicated application)
- Product Presentation
  - M24SR presentation item
- Product feature
  - RF Disable item
  - GPO control item
  - Password item
- Software version information
  - Disclaimer item

Figure 3. Main menu (Premium edition)

Figure 4. Main menu (Standard edition)
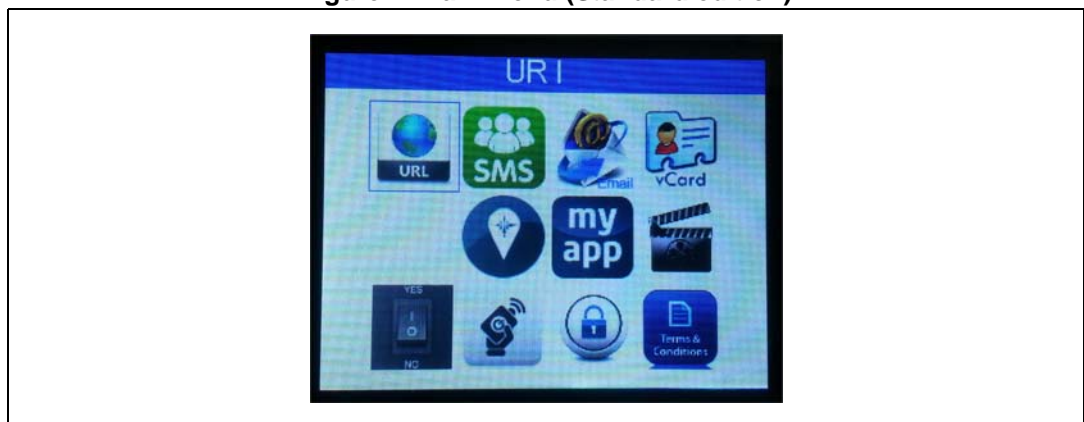
To select a use case, move the blue square on the icon of your choice using the joystick and press it to select the item.

As this document purpose is to illustrate the firmware behavior, the next item description has been chosen to explain it from an MCU point of view.

2.2   URI item

Figure 5. URI item

This menu presents how to manage the URI content in the M24SR.

With the MCU, you can:

- store an URL or a phone number,
- read the M24SR content.

    If the URI has been previously stored, the following information will be displayed on the board screen: URI protocol, URI content, and optionally information.

Figure 6. URI

In the case, the M24SR content does not represent a URI; an error message will warm the user that the content in the M24SR does not represent a URI.

2.3 SMS item

Figure 7. SMS item

This menu presents how to manage an SMS content in the M24SR.

With the MCU, you can:

• store an SMS,

• read the M24SR content.

> if the SMS has been previously stored, the following information will be displayed on the board screen: Phone number, SMS message and, optionally, instruction.

Figure 8. SMS

Note: *An error message will warm the user if the M24SR content does not represent an SMS.*

2.4 Email item

Figure 9. Email item
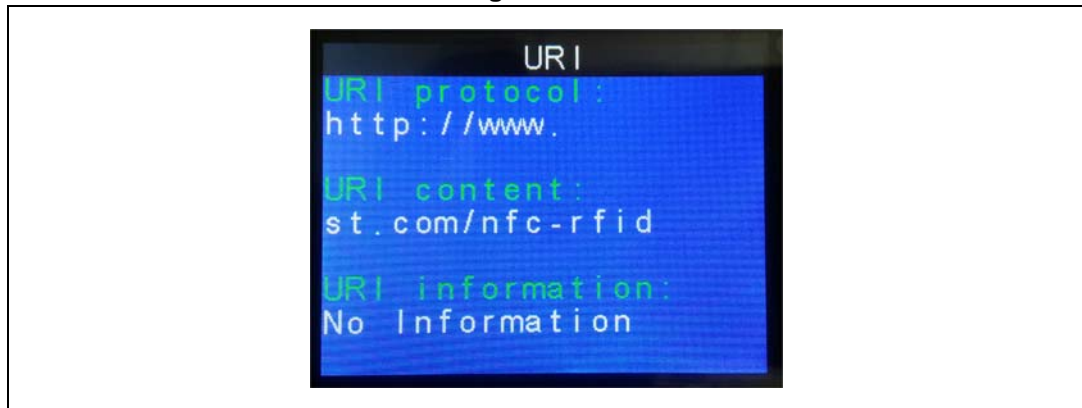

This menu presents how to manage the Email content in the M24SR.

With the MCU, you can:

- store an Email,
- read the M24SR content.

    if the Email has been previously stored, the following information will be displayed on the board screen: Email address, Email subject, and Email message.

Figure 10. Email
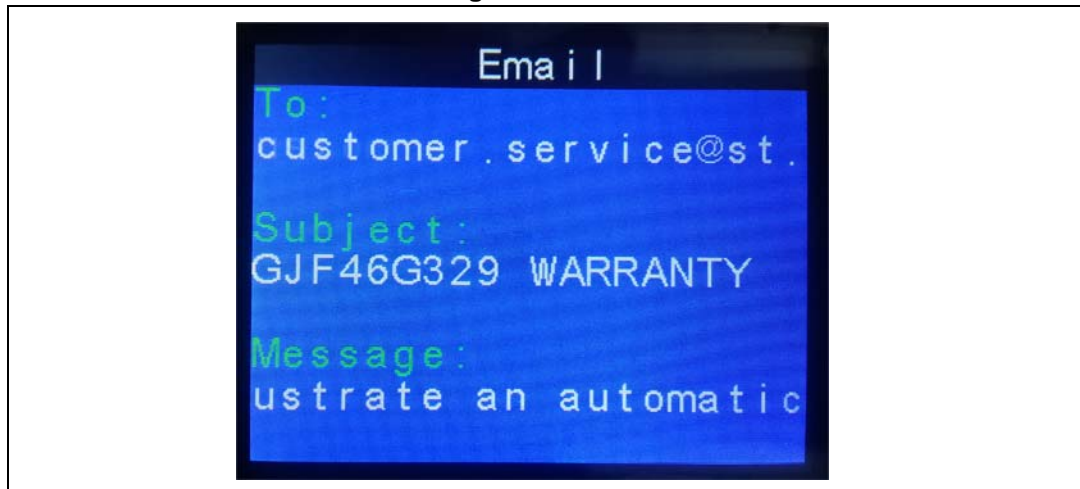
Note: *An error message will warm the user if the M24SR content does not represent an Email.*

2.5 Vcard item

Figure 11. Vcard item

This menu presents how to manage a vCard content in the M24SR.

With the MCU, you can:

- store a Vcard,
- read the M24SR content.

  If the Vcard has been previously stored, the following information will be displayed on the board screen: name, title, organization, one Phone number (cell, home tel or work tel), one address (home add or work add), one e-mail (home Email or work Email). See Remark 1.

Figure 12. Vcard
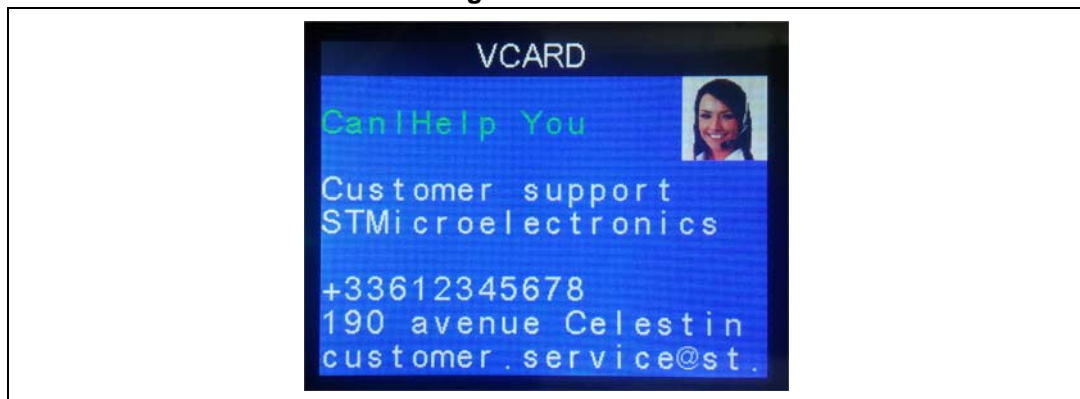
Note: *An error message will warm the user if the M24SR content does not represent a Vcard.*

Three remarks shall be considered:

1.   If the Vcard information content is too important (due to the screen limitation), a choice is made in the content display on screen.

2.   Only Vcard 2.1 has been implemented in the v1.1.1 firmware version. If you store a Vcard 3.0 in the M24SR, the firmware will warm you that it does not support this version.

3.   The firmware does not embed a jpg decoder. if you download a Vcard with a smartphone to the M24SR with a picture inside, the firmware will retrieve the data and display it but will replace the picture by a default embedded one.

2.6   Bluetooth pairing item (only on the Premium edition)

Figure 13. Bluetooth pairing item

This menu presents how to manage a Bluetooth pairing content in the M24SR.

For this example, only storing data with an MCU and reading it with a smartphone makes sense.

Note: *Your smartphone must have the Bluetooth capability.*

The BT menu has 3 options:

•   Configure the M24SR for a BT pairing operation

•   Song information

•   Possibility to pair a new device

1. **Configure the M24SR for a BT pairing operation**

   With an MCU, you can store the Bluetooth mac address of the chip in the M24SR.

   Then if you bring your smartphone close to the M24SR, your smartphone will automatically connect to the M24SR-DISCOVERY Bluetooth chip.

2. **Song information** (provided that you have an MP3 with song information on your smartphone, and a player installed.)

   The following events may occur just after bringing your smartphone close to the M24SR:

   – BT pairing is made

   – MP3 player is automatically started (need to be configured with BT event on smartphone side)

   – MP3 information is provided to the M24SR-DISCOVERY and displayed on screen, while music can be listened with the provided headset.

   The MP3 information managed by firmware is: title, artist, album, piste, genre and time.

   In case the MP3 does not content waiting information, the field stays blank.

   Here is an example of an MP3 containing part of the possible information the firmware is waiting for:

Figure 14. Song information example
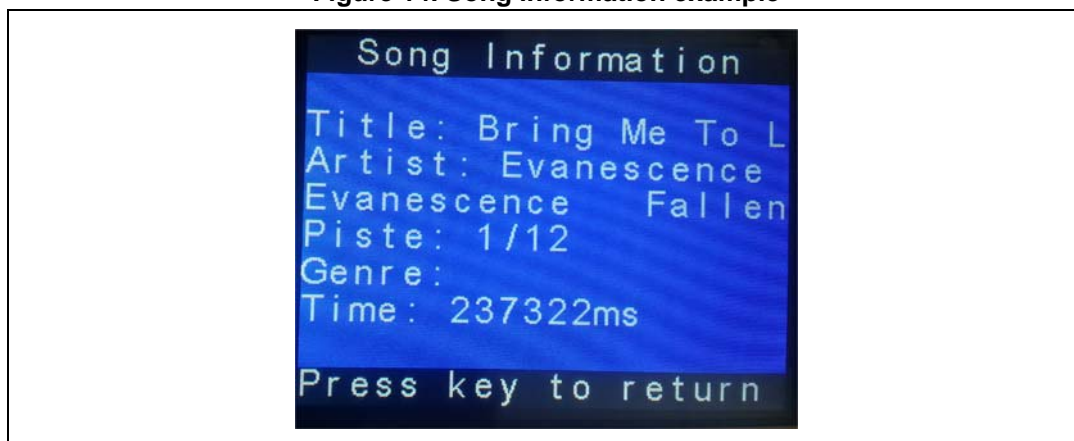
3. **Pair new device**

   This option allows the user to disconnect the Bluetooth link between the M24SR-DISCOVERY and the smartphone, and prepares the BT module to accept another connection. You can then bring a new smartphone close to the M24SR for pairing.

   Tips:

   – If the Bluetooth module is available on your board, blue LED n° 3 is ON at power-on.

   – When pairing a smartphone is allowed, LED n° 5 is blinking.

2.7 Geo item

Figure 15. Geo item

This menu presents how to manage the geolocation content in the M24SR.

With the MCU, you can:

* store a geolocation,
* read the M24SR content.

    If the geolocation has been previously stored, the following information will be displayed on the board screen: Latitude, Longitude and, optionally, some information.

Figure 16. Geolocation
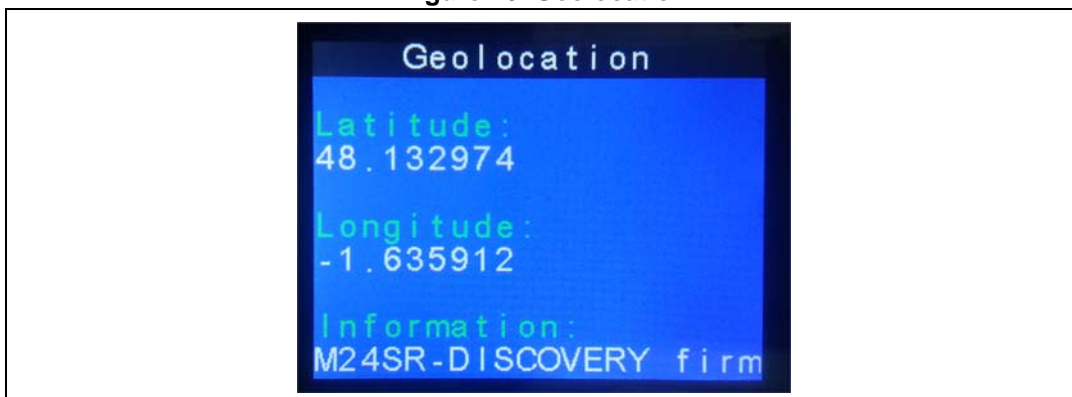
Note: *An error message will warm the user if the M24SR content does not represent a geolocation.*

2.8 My app item

Figure 17. My app item

This menu shows how to create your own application to realize your product task by using the standardized NFC forum protocol.

This is a big advantage because this means that you do not have to manage the RF part, everything being managed by your smartphone and M24SR. You just have to share your proprietary data between your application and your product equipped with the M24SR.

To illustrate this mode, an application has been developed to control the M24SR-DISCOVERY LEDs and to update the information display on the LCD.

With AAR (Android Application Record), it is possible, in the M24SR, to store a message which will automatically start the appropriate application (or will drive you to the play store to download it if you have not installed it on your smartphone).

This mechanism has been implemented in this demonstration: after selecting Download Phone App or Launch Demo App, the M24SR will be loaded with an AAR. Then, when bringing your smartphone close to the M24SR, the application will automatically start, let you drive the LEDs and provide your information to the M24SR-DISCOVERY, which will display it on the LCD.

Figure 18. Information provided by smartphone
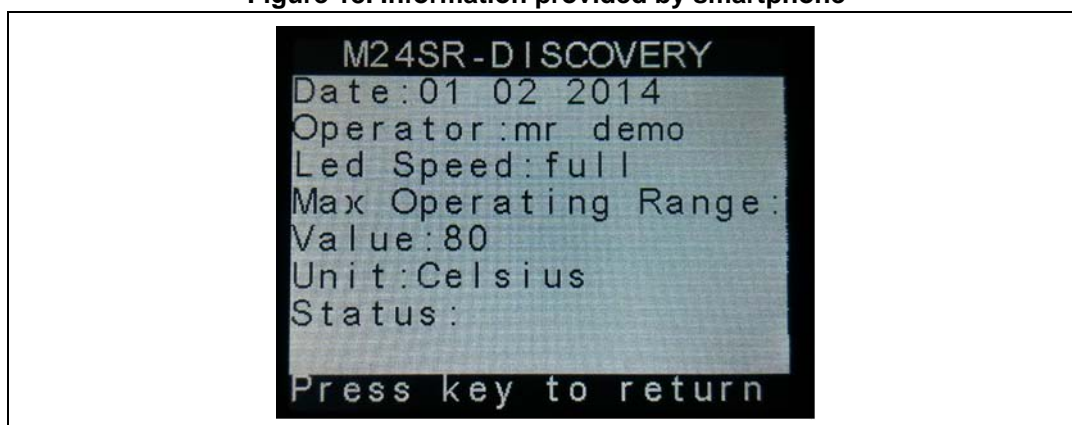
2.9 M24SR presentation item

Figure 19. M24SR presentation item

This menu shows a quick presentation of the M24SR device.

You also have the antenna matrix to inform your customers of its availability, and to help them design the antenna that will best fit their product design.

Note: *For more information, please contact us.*

2.10 M24SR RF disable item

Figure 20. M24SR RF disable item

This simple menu illustrates the possibility to disconnect the RF interface of the M24SR.

For instance, you can put content in the M24SR with your smartphone, go to the RF disable menu and disable the RF, then try to read back the M24SR content with your smartphone. The M24SR is no more detected by your smartphone.

While RF is disabled, the MCU can still access the M24SR by I^{2}C, and you can modify the M24SR content using the available menu. To modify the M24SR content, go back to the RF disable menu, enable RF, and read back the M24SR with your smartphone. The M24SR content has changed as compare to the content you initially put with your smartphone.

Tips:
–   When RF is enabled, LED n° 2 is on.
–   WHEN RF is disabled, LED n° 2 is off.

2.11 GPO control item

Figure 21. GPO control item

The M24SR provides one GPO to send interrupts to the MCU.

Before explaining the application, here is a short summary of the GPO management. (For more explanation, refer to the datasheet)

GPO has 3 different configurations regarding the M24SR state:

1.   No RF and I^{2}C session is opened on the M24SR side: GPO is not driven, GPO is high-Z but pull-upped externally on the M24SR-DISCOVERY board.

2.   An I^{2}C session is opened: the GPO behavior follows the configuration set for the I^{2}C session. This firmware demonstration is used to know when M24SR responses are available.

3.   An RF session is opened: the GPO behavior follows the configuration set for the RF session. This menu is used to send an interrupt to the MCU when RF decides to do it.

The GPO is a hardware feature which is not covered by NFC forum, so you need a dedicated feature in your application to control the GPO.

With AAR (Android Application Record), it is possible to store a message in the M24SR that will automatically start the appropriate application (or drive you to the play store to download it if you have not installed it on your smartphone).

This mechanism has been implemented in this demonstration: after selecting Download Phone App or GPO Control Demo, the M24SR will be loaded with an AAR. Then, when bringing your smartphone close to the M24SR, the application will automatically start and you will be able to drive GPO.

In this demonstration, the MCU configures the M24SR to give GPO control to the application. Each time an interrupt is generated by the application, the color of a square on the LCD changes from red to green or from green to red.

Figure 22. M24SR-DISCOVERY interrupt generation
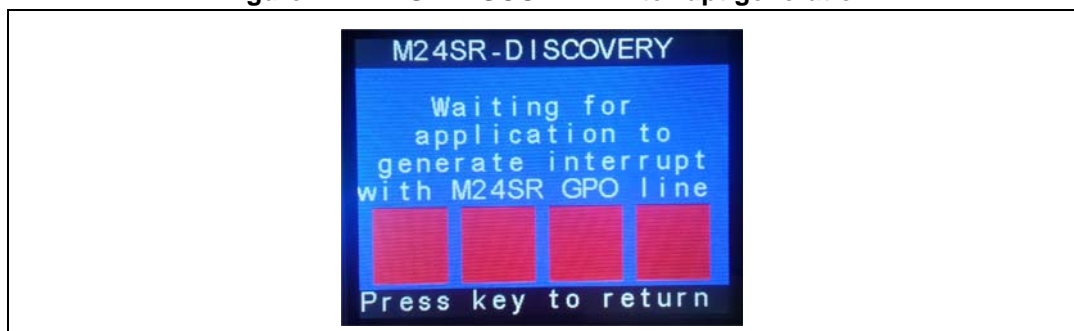
2.12 M24SR password item

Figure 23. M24SR password item

The M24SR provides a feature to set, read or/and write a password.

Before explaining the application, here is a short summary of the password management. (For more explanation, refer to the datasheet).

To understand how it works, the user must be aware of the M24SR password strategy:

- M24SR has always 2 128 bits passwords saved inside the chip (1 read password and 1 write password).
  By default the passwords are 0x00000000000000000000000000000000.

- Then, the password can be activated or not. This means that the password exists but it is not necessarily required to access the M24SR data.

- If the password is activated, it will be required when trying to access the M24SR in read or write mode (depending if the password is activated or not).

- To activate a password, the password saved in the M24SR must be presented.

- To change a read password, a write password saved in the M24SR must be presented (as it has been considered as a write operation).

- To change a write password, a write password saved in the M24SR must be presented.

- These read and write passwords can be used through I^{2}C and RF accesses.

On top of that implementation, a super user mode has been put in place by creating a super password named I^2C password (because it can be used only through the M24SR I^2C interface). This password can be used to modify read and write passwords.

Inside the M24SR password menu, you will find 3 choices: Pwd authentication, Force limited access and Super User mode.

1. For a **Pwd authentication**, you can enable or disable the use of a read or/and write password.

   As it was not convenient for the M24SR-DISCOVERY user to enter a 128-bit password, the choice has been made to create a pseudo random password to lock the M24SR content and to display it on LCD to let the user know it (see *Figure 24*).

Figure 24. M24SR-DISCOVERY password
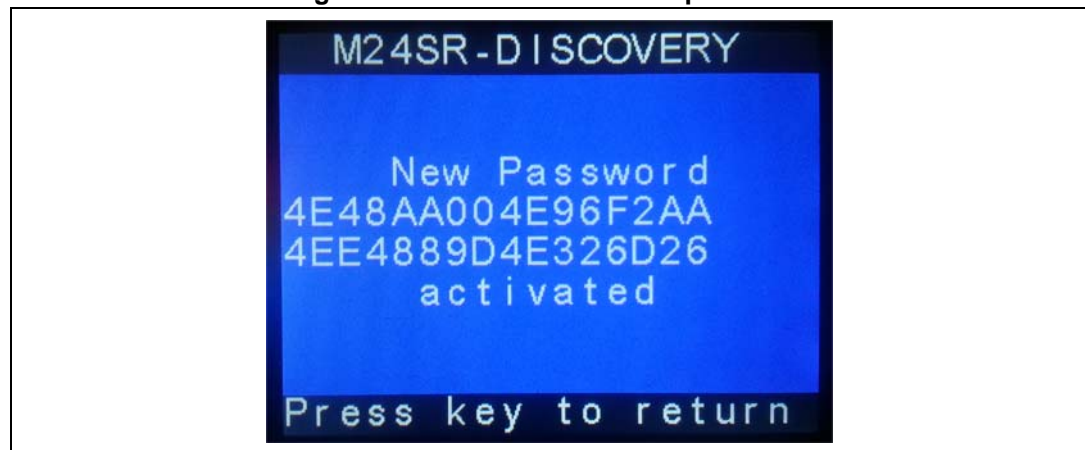
   To test the feature, you can proceed as follows:
   – Load the M24SR with an SMS content, for instance
   – Set the read password.

   If you try to read the M24SR with a smartphone, natively, it will not work.

   Use the M24SR demo application, and you will be prompted to enter the read password: enter the password displayed on the M24SR-DISCOVERY LCD display.

   The M24SR content is read by your smartphone.

   This function is adapted if you want to secure your M24SR content and let only a sterling source modifying the M24SR content. In this case, the password can be known by this reliable application.

2. The **Force limited access** can be seen as a stronger feature than a password because you can lock read or write capabilities but a reader cannot unlock it. You can set a read-only mode or a write-only mode.

   NFC forum deals with the read-only mode, and this mode will be supported by a smartphone.

   The write-only mode was not specified, so it will work only with dedicated applications.

3. The **Super User mode** uses the I^2C password to unlock the M24SR (useful if you lock the memory using the M24SR application).

Tips: When M24SR content is locked with a read or write password, the red LED n° 1 is On.

2.13 Disclaimer item

Figure 25. Disclaimer item

The purpose of this menu is just to provide the version of the firmware you are using.

Figure 26. M24SR-DISCOVERY firmware version

Appendix A   Acronym and notational conventions

Acronym

APB: Advanced Peripheral Bus

AAR: Android Application record

CAN: Controller Area Network

GPS: Global Positioning System

IEC: International electrotechnical commission

ISO: International Organization for Standardization

MCU: Micro controller unit

NFC: Near field communication

RF: Radio frequency

RFID: Radio frequency identification

RISC: Reduced Instruction Set Computer

SPI: Serial Peripheral Interface

USB: Universal serial bus

Representation of Numbers

The following conventions and notations apply in this document unless otherwise stated.

Binary number representation

Binary numbers are represented by strings of 0 and 1 digits shown with the most significant bit (MSB) on the left, the least significant bit (LSB) on the right, and "0b" added at the beginning.

Example: 0b11110101

Hexadecimal number representation

Hexadecimal numbers are represented by using numbers 0 to 9 and characters A to F, and adding "0x" at the beginning. The Most Significant Byte (MSB) is shown on the left and the Least Significant Byte (LSB) on the right.

Example: 0xF5

Decimal number representation

Decimal numbers are represented as is, without any trailing character.

Example: 245

Revision history

Table 1. Document revision history

Date	Revision	Changes
07-Feb-2014	1	Initial release.

Please Read Carefully:

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at any time, without notice.

All ST products are sold pursuant to ST's terms and conditions of sale.

Purchasers are solely responsible for the choice, selection and use of the ST products and services described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third party products or services or any intellectual property contained therein.

UNLESS OTHERWISE SET FORTH IN ST'S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE AND/OR SALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

ST PRODUCTS ARE NOT DESIGNED OR AUTHORIZED FOR USE IN: (A) SAFETY CRITICAL APPLICATIONS SUCH AS LIFE SUPPORTING, ACTIVE IMPLANTED DEVICES OR SYSTEMS WITH PRODUCT FUNCTIONAL SAFETY REQUIREMENTS; (B) AERONAUTIC APPLICATIONS; (C) AUTOMOTIVE APPLICATIONS OR ENVIRONMENTS, AND/OR (D) AEROSPACE APPLICATIONS OR ENVIRONMENTS. WHERE ST PRODUCTS ARE NOT DESIGNED FOR SUCH USE, THE PURCHASER SHALL USE PRODUCTS AT PURCHASER'S SOLE RISK, EVEN IF ST HAS BEEN INFORMED IN WRITING OF SUCH USAGE, UNLESS A PRODUCT IS EXPRESSLY DESIGNATED BY ST AS BEING INTENDED FOR "AUTOMOTIVE, AUTOMOTIVE SAFETY OR MEDICAL" INDUSTRY DOMAINS ACCORDING TO ST PRODUCT DESIGN SPECIFICATIONS. PRODUCTS FORMALLY ESCC, QML OR JAN QUALIFIED ARE DEEMED SUITABLE FOR USE IN AEROSPACE BY THE CORRESPONDING GOVERNMENTAL AGENCY.

Resale of ST products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liability of ST.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.
Information in this document supersedes and replaces all information previously supplied.
The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Philippines - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

www.st.com